

AN ANCIENT DEPLETED MANTLE SOURCE FOR ARCHEAN CRUST IN RAJASTHAN,
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Precambrian rocks exposed in the state of Rajasthan in Western India comprise the Banded Gneiss Complex (BGC) and the Aravalli and Delhi super-groups which overlie the BGC. Based on systematic mapping by Heron (1) these divisions are believed to represent major orogenic cycles; in spite of some disagreements and revisions, Heron's work remains the basic framework for interpretation of these rocks. Heron (1) considered the BGC to be the oldest unit exposed in Rajasthan. Although this has been challenged by some later workers, there is a clear erosional unconformity between the BGC and overlying metasediments and metavolcanic rocks of the Aravalli sequence in several exposures along the western margin of the BGC. Virtually no modern chronologic data are available for the BGC. However, recent Rb-Sr work on the Untala Granite, believed to be intrusive into the BGC, gave a whole rock isochron age of 2950 ± 150 my (Choudhary et al, ref. 2). We therefore undertook a geochemical and isotopic study of the BGC in the expectation that valuable data about a little-known segment of the earth's Archean crust would result.

We report here data from an initial set of BGC samples from the area east of the city of Udaipur. In this region the BGC comprises typical grey gneiss with variably abundant granitic and mafic components. We have concentrated our efforts to date on the mafic components which, based on chemical data, appear to be metavolcanic. All samples examined were recrystallized under amphibolite or upper amphibolite facies conditions. Pertinent chemical data for a small number of amphibolites analyzed so far are: SiO₂: 49-53%; MgO: 5.7-7.3%; K₂O: 0.24-0.50%; Ni: 106-140 ppm; Zr: 37-159 ppm. From Sm/Nd data, all amphibolites show small to moderate LREE enrichments.

A group of nine samples (3 gneisses, 6 amphibolites) define a Sm-Nd isochron giving an age of 3.5 AE with an initial ratio corresponding to $\epsilon_{JUV}(T) = +3.5$. Rb-Sr data for the same samples show a large amount of scatter and provide evidence for later metamorphic disturbance of the Rb-Sr system. Internal (mineral) isochrons for associated granites indicate that Sr reequilibration occurred in these rocks at 800-900 my (2,3). Structural evidence suggests at least three and possibly more major deformational episodes (e.g., Roy et al., ref. 4), so that evidence for this complex metamorphic history in the Rb-Sr system in the gneisses and amphibolites we have analyzed is not surprising.

The Sm-Nd data indicate that the amphibolites and grey gneisses are essentially cogenetic, and the 3.5 AE age must date the time of crust formation. The initial isotopic ratio for these rocks, corresponding to $\epsilon_{JUV}(T) = +3.5$, joins a growing number of examples of early crustal segments created with positive $\epsilon_{JUV}(T)$ values. If the JUV (or CHUR) reservoirs truly represent the bulk earth, then the source regions for these rocks were depleted very early in earth history. This is perhaps not very surprising since large-scale melting and accompanying fractionation must have occurred in the outer parts of the early earth. However, an important point is that the depleted source must have been preserved over a substantial period of

time in order to allow differential evolution of ^{143}Nd by as much as 3.5 ϵ units. The degree of fractionation required depends critically on the timing of fractionation. For example, for the Rajasthan data, the increase in Sm/Nd in the source compared to JUV would have to have been 16% if the differentiation occurred at 4.5 AE, and as high as 47% if it occurred at 3.8 AE. The corresponding ϵ_{JUV} values in the same source today would range from +18 to +45, respectively. Clearly such high values are not observed in the major depleted reservoir being sampled today, the MORB source. Thus either the early depleted sources were localized residues or cumulates never again sampled, or, if genetically related to the present day MORB source, the rate of increase of $^{143}\text{Nd}/^{144}\text{Nd}$ has slowed appreciably, possibly due to crustal recycling.

References

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2. Choudhary et al. (1981) Symp. Petrology, Mineral and Petrochem. in India, Geol. Surv. India Sec. 3, 51-52.
3. Crawford (1970) Can. J. Earth Sci. 7, 91-110.
4. Roy et al. (1981) Indian J. Earth Sci. 8, 119-130.